ETHER:

A BRIEF ACCOUNT OF ITS MANUFACTURE, CHEMICAL COMPOSITION, CONGEALING PROPERTIES, ETC. ETC.

BY

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ON ETHER.

By Martin Henry Payne.

While the subject of ether is on the "tapis," a few words upon its chemical composition, properties, and medicinal effects, may not be altogether unacceptable to some of the younger members of our profession. The great interest just now taken in this agent, arises from its having been brought prominently under our notice by Dr. Richardson in his recent paper on "The Anæsthetic Spray Producer"—an admirable little instrument invented by him for creating insensibility to pain, by congealing the parts upon which, by its means, the spray of ether is thrown.

In the first place, then, what is ether, and what are its chemical constituents? (2.) How is it obtained? (3.) What are its properties? And (4.) How are the latter to be explained as producing local anæsthesia through the use of the instrument in question?

(1.) Ether (from ὕλη—the material from which anything is formed) is one of the products of the distillation of alcohol with strong sulphuric acid, and is a thin, transparent, fragrant liquid, with a strong, pungent taste, having a sp. gr. 0·720 at 60° Fahr., and boiling at 96°, the barometer standing at 30. It is the oxide of a hydrocarbon, ethyl, consisting of four equivalents of carbon, five of hydrogen, and one of oxygen, or, written in chemical formula, $C_4H_{10}O$, the combining proportion being 37. The ethers may, in fact, be compared to ordinary metallic salts, in which the salt basyl, ethyl (C_4H_{10}), takes the place of a metal.

(2.) The method generally adopted in the manufacture of ether is as follows:—Alcohol and sulphuric acid are introduced into a glass retort connected with a condensing arrangement, and maintained at a brisk ebullition; and as soon as the ethereal fluid begins to pass over, fresh spirit is introduced in such quantity as to equal that which distils over. This is done by using a tube furnished with a stopcock to regulate the supply, connected by one end with a vessel containing the spirit, and raised above the level of the matrass, the other end being passed through a cork fitted to its top, and dipping into the fluid. Were it not to pass under the level of the liquid great loss of spirit would take place. A thermometer-tube is next passed through the

cork, and plunged into the liquid, by which arrangement the operator is enabled to regulate the supply of spirit, and by that means the temperature. This is the same process as that ordered in the British Pharmacopœia, excepting that—strangely enough—no mention of a thermometer is there made. The same quantity of sulphuric acid will etherise an almost unlimited amount of alcohol, for, though the acid slowly volatilizes, Fownes says that after many hours' ebullition he found that the etherifying power of the acid remained uninjured.

The next step is to deprive it of the water with which it is charged on leaving the still, and also, of a little alcohol and sulphurous acid (SO_2), and, with this object, it is agitated with caustic potash or perfectly dry chloride of calcium and a little lime, when, on being redistilled at a very gentle heat in a water bath, the ether comes over pure. It is now called "rectified," but, if necessary, this operation may be performed again and again, until the ether is obtained of the required specific gravity. According to Dr. Headland, the ether of the Pharmacopœia contains some alcohol, of which there should not be more than 8 per cent.; and this may be determined by its sp. gr., which ought not to exceed 0·735.

Thus we see that if alcohol and sulphuric acid be heated together, at a certain temperature, ether is formed, and, if the operation be performed in a retort, will be found condensed in the receiver. Now, as alcohol ($C_4H_{12}O_2$) only differs from ether ($C_4H_{10}O$) in containing the elements of one atom more water, it might be supposed at first sight, that the water was taken from the alcohol by the greater affinity of the sulphuric acid. But on further consideration, we find the process is not so simple. Ether, in fact, does not pass over alone, but mixed mechanically with water. Further, alcohol may be distilled with an excess of caustic potash, or its vapour may be passed over potassium, without any ether being produced, and yet both these bodies have a strong affinity for water, the latter at least equally so with sulphuric acid. Now, when the alcohol and acid are heated together the latter combines with the former and forms a new acid, termed sulphovinic, or, as some have it, a new compound, the bisulphate of the oxide of ethyl—

$$C_4H_{12}O_2 + 2(H_2O,\ SO_3) + Aq. = C_4H\ \ O,\ 2SO_3,\ H_2O$$
$$+ 2H_2O + Aq.$$

which, when further heated, suffers decomposition, and yields products which differ with the temperature to which the liquid has been subjected.

If the acid be so far diluted as to boil at 260° Fahr., or before, and distilled, it splits up into sulphuric acid, water, and

alcohol, while only a trace of ether is formed; if, on the contrary, it boils at a temperature varying from 260° to 310°, the liquid suffers decomposition into sulphuric acid, water, and ether, with only a trace of alcohol; but if by the addition of a large quantity of acid, the liquid is made to boil at 320°, or above, the production of ether stops, and a number of empyreumatic products are formed, amongst which are olefiant gas (or heavy carburetted hydrogen), C_2H_4, and heavy oil of wine, $C_8H_{18}O,2SO_3$.

Thus, we find that the required temperature for the production of ether is from 260° to 310° Fahr., and that the temperature of the boiling-point of the liquid depends upon the proportion in which the acid and spirit are mixed. Nor will this surprise us when we consider that sulphuric acid boils at 620° Fahr., while the boiling-point of alcohol is only 173°. Chemists have now determined that the nearer the temperature is kept to 280° the purer the product will be; but were an ordinary distilling apparatus to be alone used, the temperature on commencing the operation would be far too low, and, as it proceeded, the ether distilling, and the liquid becoming more and more concentrated, the temperature would rise considerably above the standard. It was to obviate this inconvenience that the compensation arrangement was introduced, and is now universally adopted.

There are many varieties of ether, for the action of nearly every acid on alcohol yields a different kind; thus, we have nitrous and nitric ether, oxalic ether, hydriodic ether, &c. &c. These are called compound ethers, and may be compared either to an oxysalt, consisting of the oxide of ethyl (*i. e.* ether) and an oxygen acid, *e. g.*—

$$C_4H_{10}O + H_2O, N_2O_5 = C_4H_{10}O,N_2O_5 + H_2O;$$

or forms a haloid salt, with a hydrogen acid, *e. g.*—

$$2HI + C_4H_{10}O = C_4H_{10}I_2 + H_2O.$$

They may generally be made by the direct action of the acid, but no compound ether has as yet been produced from ethyl.

(3.) The ether more especially under our consideration used to be called sulphuric, from the acid with which it is made, and may still be procured under that name; but among chemists the term has been superseded for that of *vinous*, or—"par excellence"—Ether. It is very combustible, burning with a yellowish-white flame, and generating water and carbonic acid, from its carbon and hydrogen combining with the oxygen of the air. Its vapour is very heavy, having a density of 2·586; this, mixed in certain proportions with oxygen or atmospheric air, forms an explosive compound, and from an unfortunate ignorance of this fact many serious

accidents have already occurred. It is a solvent of many resins, fixed and volatile oils, caoutchouc, and most of the vegetable alkaloids,—and also dissolves, but less readily, sulphur and phosphorus. It is sometimes adulterated with rectified spirit, and to a small extent with water, with which, however, it is miscible to a very limited extent, 100 parts of the former dissolving but 10 of the latter.

Should it take up a much greater quantity, the ether is impure, and is probably mixed with alcohol, from which it may be separated by the addition of a small quantity of water, which, combining with the spirit, forms two distinct but easily separated layers. Pure ether is perfectly neutral to test-paper, and is largely employed in the analytical laboratory, as a solvent for fatty and oily substances; it is also largely consumed by photographers, as one of the principal ingredients in the manufacture of collodion.

Two other important properties of ether may here be mentioned:—First, its power of dissolving iodine and bromine; and, secondly, that of dissolving the perchloride of mercury, HgCl* (corrosive sublimate). The value of the first will be easily appreciated when we consider that our means of obtaining bromine from the sea-water, and from various saline springs, where it exists chiefly as bromide of magnesium, depend upon that property.

The next, namely, that of dissolving the chloride of mercury, is likewise a very important one; and inasmuch as it is unable to dissolve the subchloride Hg_2Cl (calomel), it furnishes us with a valuable means of ascertaining the freedom of the latter salt from the chloride, with which in its course of manufacture it is frequently contaminated; it also gives us one way, at least, of separating the two substances.

Ether is used internally as a stimulant, antispasmodic, and narcotic, but is unaccompanied by subsequent depression. Dr. Headland states that it is especially useful in hysterical and in nervous complaints, generally in doses of ♏xv to ʒi, especially if prescribed with laudanum, or with a solution of the salts of morphia. The first effect of ether when inhaled is to exhilarate, but when taken in sufficient quantity it produces perfect insensibility. It was formerly used as an anæsthetic, but though still preferred by many to chloroform, has been almost entirely superseded by the latter agent in this country.

There are other uses to which ether may be applied, both in the surgery and in the laboratory of the chemist; but as they do not bear on the subject before us, I shall not introduce them here.

* The equivalent of mercury is taken at 100.

Mr. Squire devised the first apparatus for inhaling ether, which he has presented to the Museum of London University College. He relates that this instrument was first used by Mr. Liston in an operation for amputation, the patient not suffering the least pain; "Nor, indeed," he continues to say, "could he be persuaded that his leg was off, even after the return of consciousness, until he felt for it."

In a recent number of the 'Medical Times and Gazette,' Dr. Richardson has published a series of tests for ascertaining the purity of ether. He says, "All the ordinary ethers of the shops contain alcohol, the presence of which substance materially interferes with the success of the process. It prevents perfect anæsthesia, and causes a tingling and burning sensation at the beginning of the process, and during the brief period of reaction."

He gives the following simple tests for ether:—

(A) Take the specific gravity. The specific gravity should not exceed 0·723.

(B) Try the boiling point. Warm the hands by gently blowing into them the warm breath. When the hands feel as warm as the breath, make the palm of one hand into a cup and pour in one or two drachms of ether. The ether ought immediately to boil briskly, without giving any pain.

(C) Test the effect on mucous membrane. Put one or two drachms of the ether in the palm of the hand, and quickly take up the ether into the mouth with the tongue. The ether should at once pass off, leaving neither smarting nor burning, nor any sensation except a slight coldness.

(D) Pour a little of the ether on a piece of clean white blotting-paper, and lay the blotting-paper on the warm hand. The paper should dry within a minute, leaving no moisture and no smell whatever. If the paper, while drying, yield an odour like eau de Cologne, there is some alcohol present. If it give a smell slightly pungent, and which hangs about for a time, there is some methylated compound present. Perfectly pure ether, in a word, leaves no persistent odour.

(E) Try the degree of cold producible by the ether. Charge the bottle connected with the spray producer, and direct the spray on the bulb of a thermometer. The mercury ought to fall rapidly to six degrees below zero Fahr., and the falling of the mercury should continue until there is a deposit of snow on the bulb of the thermometer from condensation of water in the air.

(F) Test the effect on the skin. Direct the spray, at a distance varying from half an inch to an inch and a half from the jet, on the back of the hand. In a space of time, extending from thirty seconds to two minutes, a slight hoar

frost deposit should form on the skin, followed immediately by a diffuse blanching. The skin is at this moment altogether insensible.

(G) Test the reaction of ether by litmus. The reaction should be neutral.

These are the ready and necessary tests. A pure ether answers to all of them, and no other ether ought to be used.

Dr. Richardson states moreover that he has applied the local anæsthesia in forty-three minor operations with a result of complete success in thirty-six cases and with more than partial success in the remainder. He says that in those cases where the result has not been complete, the failure has been due to imperfection either in the ether or apparatus, or to deficient experience—unavoidable in all preliminary inquiries. The reaction has been rapid, painless, and satisfactory.

We now come to the last question—

(4.) How are its properties as a local anæsthetic explained? That they are obtained by congelation, more or less perfect, as the operation has been more or less satisfactorily performed, requires no demonstration. But the question before us is—How the great cold requisite for congelation is produced? and this I will endeavour to explain.

When any given solid body becomes liquid, a certain fixed and definite amount of heat becomes latent, *i. e.*, becomes absorbed, and is not indicated by the thermometer. The latent heat of water is 142°·65—that is to say, that if equal weights of snow or ice be mixed with water at 174° (*i. e.*, 142° + 32°), the ice will be melted, but the temperature of the mixture will not be the *mean* of the two temperatures, as would have been the case if *two liquids* of different temperatures had been mixed, but the water will be only 32°, or the same temperature as the ice. The question now naturally arises—what has then become of the 142° which appear to have been lost? The answer is, they have become latent or disguised. No matter at what temperature the ice may be exposed, the water flowing therefrom will remain at a uniform temperature of 32° Fahr., until all the ice is melted. The additional heat is required by the solid body before it can become liquid; in short, it appears as though all its influence was required to hold the body in the liquid state, and hence was unable to exert any on surrounding objects. In the same manner that substances absorb heat in passing from a solid to a liquid form, so also do liquids in passing into the gaseous state. A common illustration may be found in boiling water; the temperature rises till it reaches 212°, when it begins to boil: but when once that degree is reached the thermometer remains stationary whilst there is any liquid left in the

vessel. This phenomenon is explained by saying that the temperature over and above 212°, which is requisite to keep it in ebullition, was rendered latent.

The latent heat of steam is 960°·6, or in other words, if the heat disguised in steam were set at liberty, and permitted to exert its influence on the bulb of a thermometer, the mercury would rise for a similar number of degrees. Thus bodies, whether liquid or gaseous, may be considered as chemical compounds, in which, as Dr. Wilson observes, liquids consist of solids + heat, and gases of liquids + heat; and as chemical compounds, the elements cease to present the same properties as before combination. When bodies are passing from one state to another the requisite heat is taken from surrounding objects, in which the temperature falls proportionally; and the more volatile a liquid is, the greater is the amount of heat taken in a given time from any one neighbouring body, and the less time have they in which to recover their equilibrium—by borrowing in their turn—and consequently the more rapily the thermometer falls.

In Dr. Richardson's instrument, in which ether (one of the most volatile substances known) of a very low specific gravity is used, evaporation is further aided by being thrown off in the form of a very fine spray, thus exerting its influence over a large surface.

The mercury in the bulb of an ordinary thermometer may be frozen by it in about a minute, which is about the time used in operations in Dental Surgery, and so far, at least as my own personal observation has gone—ʒj to ♏lxx is the usual quantity employed; at the same time, instances occur when it is necessary to nearly double the time in order to obtain the same results.

In conclusion, I will merely add that the action of the ether, as applied to Dental purposes, appears to be partly narcotic, as well as anæsthetic.

In the preceding paper I have employed the new atomic weights in which the equivalents of oxygen, sulphur, and carbon have been doubled, so that the formula for water would no longer be expressed by HO, as formerly, but by H_2O or $\begin{matrix}H\\H\end{matrix}O$.